US005240006A

United States Patent [19]

Fujii et al.

[11] **Patent Number: 5,240,006**

[45] **Date of Patent: Aug. 31, 1993**

[54] **APPARATUS FOR DISPLAYING A BLOODSTREAM STATE**

[75] Inventors: **Hitoshi Fujii**, Fukuoka; **Hideo Tomoda**, Tokyo; **Takashi Yokokura**, Tokyo; **Masaru Satoh**, Tokyo, all of Japan

[73] Assignees: **Hitoshi Fujii**, Fukuoka; **Kabushiki Kaisha Topcon**, Tokyo, both of Japan

[21] Appl. No.: **704,431**

[22] Filed: **May 23, 1991**

[30] **Foreign Application Priority Data**

May 24, 1990 [JP] Japan 2-134860

[51] **Int. Cl.**[5] **A61B 5/0265**; A61B 3/10

[52] **U.S. Cl.** **128/665**; 128/691; 128/687; 351/221

[58] **Field of Search** 128/633, 664, 687, 676, 128/688, 689, 691, 665–667; 351/221

[56] **References Cited**

U.S. PATENT DOCUMENTS

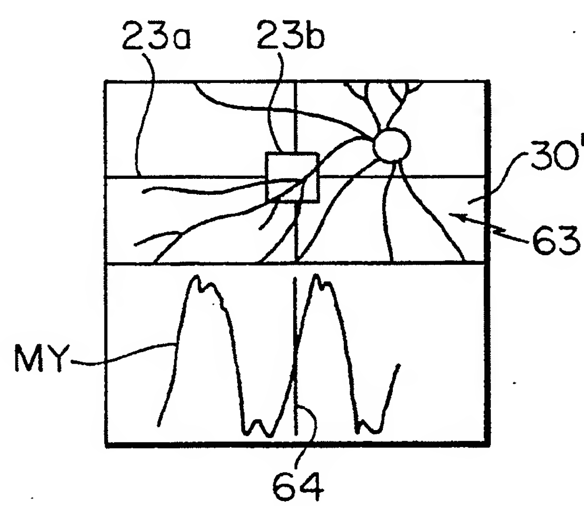
4,877,322 10/1989 Hill 351/221
5,042,939 8/1991 Zayek 351/206
5,090,799 2/1992 Mikano et al. 351/221
5,106,184 4/1992 Milbocker 351/221

Primary Examiner—Lee S. Cohen
Assistant Examiner—Kevin Pontius
Attorney, Agent, or Firm—Finnegan, Henderson, Farabow, Garrett & Dunner

[57] **ABSTRACT**

An apparatus for imaging and displaying a blood stream state of an eye to be tested. A laser beam is first irradiated onto an eye to be tested. And light reflected from an irradiated area on the eye is detected and information about the reflected light is stored. And second, the bloodstream state of the eye are calculated on the basis of the information, the imaged results are displayed on a display means of the apparatus. At the same time, a pulse wave of a person to be tested is detected by a pulse wave detecting means, the wave shaped of the pulse wave is displayed by a display controlling means, which controls to display the measuring time and portion of the bloodstream state compositely on the present wave shape.

5 Claims, 5 Drawing Sheets



55321

מדינת ישראל
משרד המשפטים

רשות הפטנטים

פ.ק. 25

תאריך: י״ז כסלו תשס״ט
14.12.2008

מספרכם: 55321

ס. קולב ושות'
עורכי-דין ועורכי פטנטים
16 -12- 2008
נתקבל
רחובות

לכבוד
סנפורד ט. קולב ושות'
שער הגיא 4, מרמורק
רחובות 76122
2273

א.ג.נ.,

הנדון: **הודעה על ליקויים בבקשת פטנט מס' 168962**
סימוכין: מכתבכם מיום 02/09/2008

לתשומת לבכם: מקום בו הנכם מופנים לחוק, הכוונה היא לחוק הפטנטים, התשכ״ז – 1967. מקום בו הנכם מופנים לתקנות, הכוונה היא לתקנות הפטנטים (נוהלי הלשכה, סדרי דין, מסמכים ואגרות), התשכ״ח – 1968. בהתאם להוראות תקנה 41 הנני להודיעכם כי נמצאו בבקשה הנ״ל הליקויים המפורטים להלן.
עליכם להשיב על הודעה זו תוך ארבעה חודשים מתאריכה, אך הנכם רשאים לבקש את הארכת התקופה. עם בקשה כאמור שתוגש לפני תום התקופה יש לשלם אגרה בסך 57 ש״ח בעד כל חודש או חלק ממנו.

ואלה הליקויים:

1. מערכת התביעות בבקשה דנן כוללת 7 תביעות בילתי תלויות. 4 מהן התובעות שיטה ו-3 מהן התובעות התקן. זאת בניגוד להחלטת הרשם הקובע כי על מערכת התביעות לכלול תביעה אחת או שתיים לשיטה ואחת או שתיים להתקן (ראו מסמך מצורף).

2. התביעה הראשונה במערכת התביעות של הבקשה דנן מגדירה שיטה לאיבחון כלי דם בנבדק הכוללת את הפעולות הבאות:

   a. optically imaging… a blood vessel
   b. determining from said optical imaging… flow characteristic of erythrocytes…
   c. utilizing said… flow characteristic for determining roughness on said inner wall of said… blood vessel

באמצעות תכונות אלו ניתן להשיג את מטרת האמצאה: שיטה לאפיון עובי הדופן הפנימית של כלי דם ע״י הדמיה אופטית של דפוסי זרימת כדוריות הדם האדומות בכלי הדם.

3. אולם ניתן לציין שיטות ידועות הכוללות את הפעולות הנ״ל ומיועדות לאותה מטרה. ראו, למשל:
   i. US5240006.

רח' הסדנא 4, תלפיות, ירושלים 93420
טל': 972-2-5651666 פקס: 972-2-5651641

בפטנט זה מתואר התקן לחדמיית אופטית של זרימת הדם בעין באמצעות לייזר ואיבחון מחלות בכלי הדם (לדוגי טרשת עורקים) עייי מידע זה.

ii. וכן ראו:

U. Selfert, W. Vilser,: "Retinal Vessel Analyzer (RVA) -Design and Function", Biomed Tech Vol 47, Suppl. 1, 2002

בפרסום זה מתוארים התקן ושיטה לאיבחון כלי דם בעין עייי הארה אופטית ומתוך כך קביעת קוטרם וזיהוי חסימות או הרחבות בהם.

4. לאור האמור לעיל, לא נמצא חידוש באמצאה הנתבעת בתביעה הראשונה של הבקשה דנן, לפי סעיף 4 לחוק.

5. עייפ סעיף 18 לחוק, נבקשכם להודיענו על ציטוטים נוספים, אם התקבלו.

בכבוד רב,
פאינה טרנופולסקי
בוחנת ראשית

לוט:
- ☐ מקור הפירוט
- ☐ שרטוטים — גיליונות מסי
- ☒ תצלומים 3
- ☐ דף(ים) מסי
- ☐ מסמכים אחרים:

RETINAL VESSEL ANALYZER (RVA) - DESIGN AND FUNCTION

B.-U. Seifertl[1], W. Vilser[1,2]

[1]IMEDOS GmbH, Weimar, Germany
[2]Technical University of Ilmenau, Ilmenau, Germany

b.seifert@imedos.de

Abstract— The Retinal Vessel Analyzer (RVA) is a measuring device for online measurement of the diameter of retinal vessels in relation to time and locations along the vessel. It is furthermore provided with several tools for analyzing the measured data. The fundamental components consist of a fundus camera with CCD measuring camera attached and an advanced image-processing unit. The measurement range is from 90µm, temporal resolution is 40ms and measurement resolution is less than 1µm. Systematic error of non-linearity is S≤1,6%, reproducibility is given by variation coefficient: short term vc_s=1,5%, long term vc_l=2,8%.
(Supp. BMBF- 13N7999)

Keywords— RVA, Retina, Microcirculation; Vessel Analysis

Introduction

In the field of retinal diagnosis there is an increasing demand for early recognition of pathological changes. One promising way is the observation of the dynamic behavior of the vessels in the retina. Vessel diameter is considered to play an important role within the auto regulative mechanisms. It is the adjusting element of the local regulation and furthermore a point of attack for pathological, age related or therapeutic changes. Diagnostic relevant information may be obtained by provocating the retinal microcirculation and measuring vessel diameter response to that provocation. A dedicated analysis of the measurement results gives an insight into different auto regulative mechanisms, which compensate for disturbances of or demands on microcirculation. Changes in auto regulative reserve could be used for early recognition.

Whereas several other research groups working in the field of image based retinal diagnostics perform single image analysis dynamic regulation processes in microcirculation only become assessable by continuous measuring methods. RVA enables the measurement of the dynamic behavior of the vessel diameter [1], therewith providing a suitable tool for several diagnostic and research applications.

An essential part of the RVA is the fundus camera (FF450, Zeiss Jena, Germany). This optical instrument enables the examination of the background area of the eye. It incorporates two optical pathways, the illumination pathway and the observation pathway. Both of them use the (dilated) pupil as an entrance to the patient's eye. The illumination light reflected by the different layers of the retina is delivered to an observation ocular and the measuring CCD-camera simultaneously. When passing the vessels in the background of the eye one part of light is absorbed by the red blood cells. Choosing the appropriate illumination wavelength big vessels can be easily detected in the retina's image.

Materials and Methods

RVA as a tool for retinal diagnosis and research is performing two major tasks: firstly creating the data basis of measured values and secondly the analysis of those measurements. In Fig. 1 the principle setup of the device is shown.

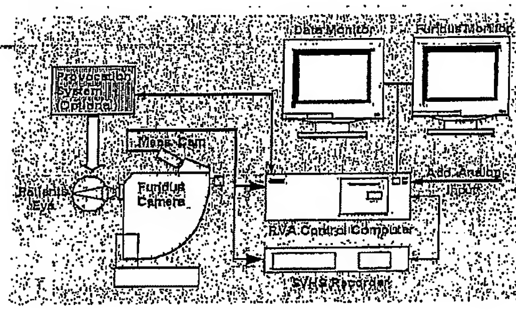


Fig. 1 RVA Principle Setup

RVA - Design

An essential part of the RVA is the fundus camera (FF450, Zeiss Jena, Germany). This optical instrument enables the examination of the background area of the eye. It incorporates two optical pathways, the illumination pathway and the observation pathway. Both of them use the (dilated) pupil as an entrance to the patient's eye. The illumination light reflected by the different layers of the retina is imaged to the measuring CCD-camera. When passing the vessels in the background of the eye one part of light is absorbed by the red blood cells. Choosing the appropriate illumination wavelength big vessels can be detected in the retina's image.

A CCD-measuring cam applied to the optical pathway of the fundus camera provides both the RVA control computer and a SVHS recorder with a standard video signal. Video recording of a session enables subsequent offline measurements on the same session later on.

Two monitors come into operation. One displays the data and the actual user interface, the other one provides a live view of the fundus allowing the selection of a particular measurement area. The RVA computer is controlling all connected devices and runs the required software package

U. Seifert, W. Vilser, „Retinal Vessel Analyzer (RVA) -Design and Function", *Biomed Tech* Vol 47, Suppl. 1, 2002

consisting of measurement and analysis programs, a database system and the filing software.

To achieve an optimum contrast for vessel visualization a special green filter is inserted into the illumination pathway of the fundus camera. Illumination source is the common halogen bulb of the camera.

As an option the system can be equipped with one of several possible provocation methods, e.g. intraocular pressure enhancement, pure oxygen breathing or flicker light. Additional analog inputs of the RVA computer can record data from those provocational systems to track the course of provocation for analysis purposes.

RVA – Measuring Principle

To explain the measuring principle of the RVA some remarks regarding the vessel structure and the origin of the vessel image are necessary. Illumination light from the fundus camera entering the eye's pupil is reflected by the retina. The vessels on the surface of the retina are filled with blood absorbing a certain amount of the reflected light. Fig. 2 shows the vessel structure in principle.

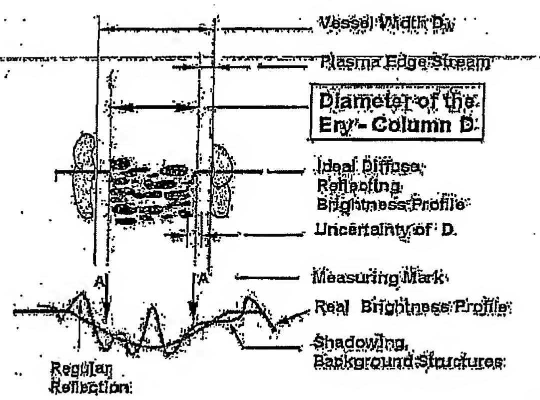


Fig. 2 Vessel Diameter Definition

Inside the vessel walls that are invisible for the fundus camera under imaging conditions, there is the column of red blood cells. It is separated from the walls by the plasma edge stream. Ideal conditions assumed a homogenous distribution of the red blood cells results into the ideal diffuse reflecting brightness profile. In reality there are several disturbances of that model e.g. shadowing structures from the background or regular reflections on the vessel surface leading to the real reflecting brightness profile. Measurement algorithms of the RVA assess vessel diameter from brightness profiles and have to compensate for disturbances. In general adaptive algorithms of the RVA perform the following tasks:

- Detection of a vessel.
- Assessment of the photometric center of gravity of the distance between the vessel edges.
- Correction of vessel sloping position.
- Monitoring of general image quality and vessel attributes to assure reasonable measurements.

A definition for the vessel diameter measured by the RVA can be given as: RVA measures the diameter of the column of red blood cells. By way of contrast the distance from wall to wall is defined as vessel width, as assessed for instance by means of fluorescence angiographies.

RVA – Measuring Procedure

Before a measurement session on the RVA can be started the fundus camera has to be properly adjusted to the patient's mydriatic eye. The life monitor should display a fundus image of good contrast without reflections. The examination method and duration is selected. To decrease the amount of acquired data the temporal resolution can be set to values higher than 40ms. After defining the measurement area by dragging a region of interest over a vessel on the life monitor the measurement can be started by mouse click. By means of a fixation target the patient's viewing direction should be guided in such a way that the vessels to be measured are close to the center of the live image. If the measurement area contains more than one vessel the diameter is determined for every particular vessel simultaneously. During measurement the diameter run for the selected vessels is displayed online on the data monitor.

RVA – Data Basis

Continuous recording of the vessel diameter during a measurement session results in a measuring data basis, available for further analysis after the end of the measurement. It can be displayed in a diagram like shown in Fig. 3.

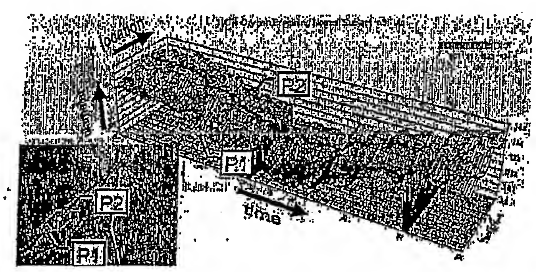


Fig. 3 RVA Data Basis (Dashed Line: Local Course Representation of Vessel Diameter)

With a temporal resolution of 40 ms one mean diameter value from 10 pixel columns is assessed and the location along the vessel is altered randomly. Therefore three dimensions represent the run of the vessel diameter along the vessel location as well as along the time course. As an example the dashed line in the diagram shows the mean run of the diameter inside a given time period between to points on a vessel that correspond to the points inside the measurement area on a fundus image. Displaying that part of the RVA data basis in a two dimensional diagram results in the local course view like shown in Fig. 4.

Constrictions and Dilatations on the vessel section can be detected that way.

APPARATUS FOR DISPLAYING A BLOODSTREAM STATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for two-dimensionally imaging and displaying a bloodstream state of a retina, an iris and so forth by measurement of a laser beam and consideration of a change of the bloodstream based on a change of a pulse wave.

2. Description of the Prior Art

One of well-known conventional methods for observing a bloodstream state of an eye is a method by Doppler effect of a laser beam reflected from a retina, and another by photographing of speck patterns of the reflected laser beam.

An apparatus for imaging and displaying the bloodstream state is recently being improved in the cause of advantages as follows:

It permits of a direct observation of a bloodstream state in a blood vessel without injuring an eye to be tested. Since a state of an obstruction in the blood vessel can be observed by information of the speed of bloodstream, the bloodstream states before and after an operation for diabetic retinitis with the optical coagulation can be compared in detail, so that an infallible cure is taken.

It is effective in diagnosis of adult diseases such as high blood pressure or arteriosclerosis on the analogy of a state of an eye thereby.

It is effective in diagnosis of a circulatory disease of an aortic syndrome, a brain circulatory disease and so forth.

BRIEF SUMMARY OF THE INVENTION

A human pulse rate is usually 60 to 120 per minutes (or 1 to 2 per second), and the shortest period of the pulse wave has at least 500 milliseconds. Therefore, when the state of the bloodstream of an iris or a retina, for example, are imaged and displayed, the speed of bloodstream on the wave peaks is relatively higher than that upon the wave trough in the case of measurement upon the peak of the pulse wave; conversely the speed upon the trough is relatively lower than that upon the peak in the case of measurement upon the trough. And accordingly, measurement without due consideration for a change of the pulse wave results in the unreliability.

The average speed of bloodstream may be obtained by measurement during a period from the peak to the next peak of a pulse wave (or during one cycle). An an eye to be tested must be in a fixed stare at least for one minute so as to maintain the accurate measurement of the bloodstream at the same height on the pulse wave when measured. It is, however, difficult owing to continuous slightest tremors of an eye. Furthermore, the operation is complicated and requires a skilled operator.

An object of the invention is to provide an apparatus for imaging a bloodstream state capable of gaining most reliable measured results of a bloodstream state of an eye to be tested, considering a change of the pulse wave in the meantime. To accomplish it, the apparatus comprises pulse wave detecting means for displaying a pulse wave of a person to be tested, display means for displaying the pulse wave together with the imaged bloodstream state on the display means for displaying a bloodstream state of an eye to be tested, and display

controlling means for making the display means display measuring time and portion compositely on the pulse wave.

In an apparatus for displaying a bloodstream state according to the invention, a laser beam is irradiated onto an eye to be tested and light reflected from the irradiated area on the eye is detected and information about the reflected light is stored. The bloodstream state of the eye is calculated on the basis of the stored information, the imaged calculations are displayed on display means. At the same time, a pulse wave of a person to be tested is detected by pulse wave detecting means. The wave shape of the pulse wave is displayed by display controlling means which controls to display the measuring time and portion of the eye compositely on the present wave shape.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an optical system of an apparatus for imaging a bloodstream state according to the invention.

FIG. 2 shows a partially enlarged view of FIG. 1.

FIG. 3 shows a block diagram of a controlling section of an apparatus according to the invention.

FIG. 4 shows a flow diagram illustrating consecutive processes of an apparatus according to the invention.

FIG. 5 through FIG. 8 show images on image-display means according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference will now be made in detail to the presently preferred embodiment of the invention as illustrated in the accompanying drawings.

Referring to FIG. 1, the reference numbers 1, 2, 3 designate an illuminating system for observation and photographing, an optical system for observation and photographing, and an optical system for measurement, respectively.

The illuminating system for observation and photographing 1 includes an illuminating source for observation 4, an illuminating source for photographing 5, condenser lenses 6, 7, an infrared raysimpermeable and visible rays-permeable filter 8, a ring slit 9, an oblique mirror 10, and a relay lens 11. The sources 4 and 5 are conjugate with the condenser lens 6, and the ring slit 9 is approximately conjugate with a pupil 13 of an eye to be tested.

The optical system for observation and photographing 2 includes an objective lens 14, a dichroic mirror 15, a perforated mirror 16, a diaphragm 17, an auxiliary lens 18 for compensating refractive indexes, a relay lens 19, a diaphragm 19−, a condenser lens 20, a half mirror 21, a quick return mirror 22, a reticule projecting optical system 23, a TV camera 24, and a film 25.

The dichroic mirror 15 reflects only a laser beam of wavelength 830 nm and permeates illuminating visible rays. A light-receiving surface 24*a* of the TV camera 24 and the film 25 are conjugate with the quick return mirror 22. The mirror 22 is dislocated out of the optical path of the illuminating system for observation and photographing when photographed. The reticule projecting optical system 23 includes an illuminating source 26, a condenser lens 27, a reticule plate 28, and an image-forming lens 29. A reticule image of the reticule projecting optical system 23 can be received into the TV camera 24 through the half mirror 21 and the quick return mirror 22, and it can be imaged on the film 25.